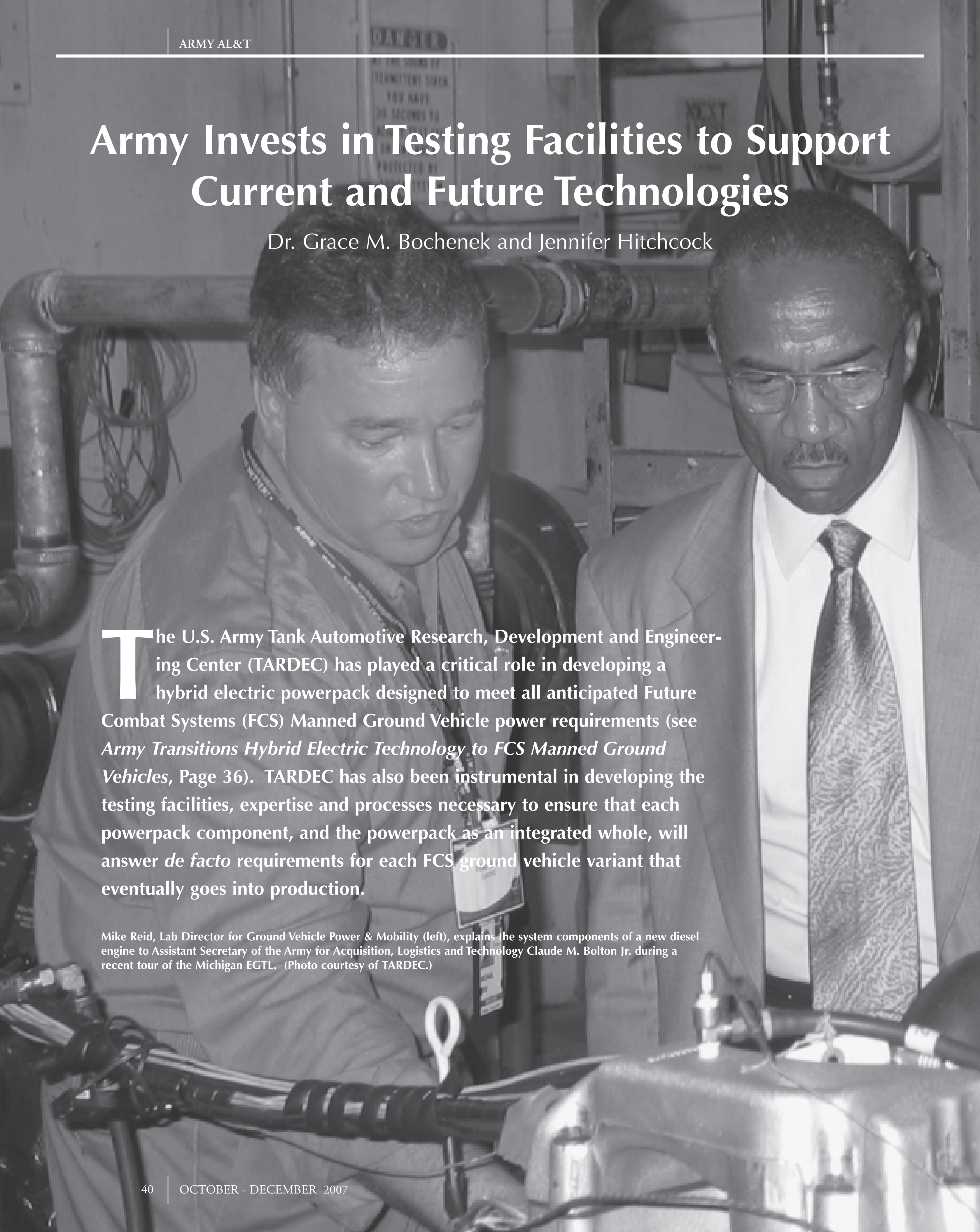
Army Invests in Testing Facilities to Support Current and Future Technologies

Dr. Grace M. Bochenek and Jennifer Hitchcock

The U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) has played a critical role in developing a hybrid electric powerpack designed to meet all anticipated Future Combat Systems (FCS) Manned Ground Vehicle power requirements (see *Army Transitions Hybrid Electric Technology to FCS Manned Ground Vehicles*, Page 36). TARDEC has also been instrumental in developing the testing facilities, expertise and processes necessary to ensure that each powerpack component, and the powerpack as an integrated whole, will answer *de facto* requirements for each FCS ground vehicle variant that eventually goes into production.



Mike Reid, Lab Director for Ground Vehicle Power & Mobility (left), explains the system components of a new diesel engine to Assistant Secretary of the Army for Acquisition, Logistics and Technology Claude M. Bolton Jr. during a recent tour of the Michigan EGTL. (Photo courtesy of TARDEC.)

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **DEC 2007**	2. REPORT TYPE	3. DATES COVERED **00-00-2007 to 00-00-2007**
4. TITLE AND SUBTITLE **Army Invests in Testing Facilities to Support Current and Future Technologies**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Army Acquisition, Logistics & Technology (AT&L),9900 Belvoir Road Suite 101,Fort Belvoir,VA,22060-5567**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Army propulsion systems are inherently expensive and time-consuming to change or upgrade once a vehicle has entered production. Successful Army transformation demands that the best possible propulsion technologies get into the vehicle development life cycle at the earliest possible juncture. Early life-cycle collaboration between Army science and technology (S&T), acquisition and industry partners makes this possible.

To successfully transition and integrate these technologies into a vehicle platform that is itself under development, it is necessary to adopt evolutionary acquisition practices and constantly test, refine and reengineer the propulsion system as the vehicle platform matures. That requires still greater collaboration between all program partners, and demands the very latest in testing instrumentation, facilities and methodologies from the S&T community.

In short, it is not enough for the S&T community to deliver a state-of-the-art product at a certain point in time. It must also be prepared to partner with program managers and chief engineers to monitor field data and to fully test and refine that product throughout the host platform's development life cycle.

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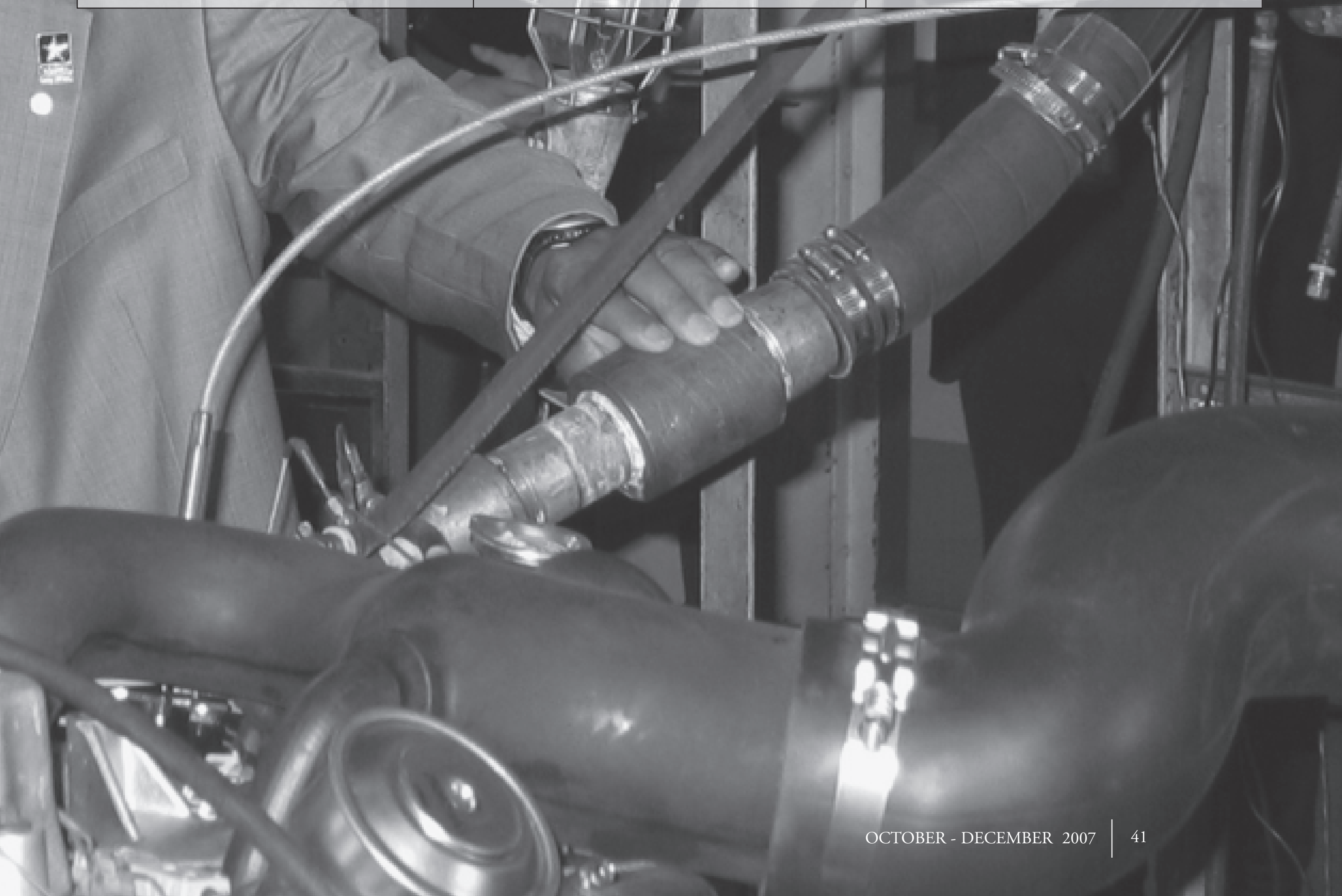
TARDEC has worked for the last decade to ensure that it can deliver on both of these requirements. The process typically begins with propulsion system component testing at government and contractor facilities to verify performance capabilities and specifications. Components are then tested at the subsystem and, finally, the entire propulsion system level. Individual components often behave much differently than intended when integrated into a system, and additional engineering work is required to resolve installed systems-level performance conflicts.

TARDEC Engine Generator Test Laboratory (EGTL)

TARDEC has been conducting component-level and subsystem testing of FCS engine/generator elements for



the past year at its Michigan EGTL. This testing includes verification of engine/generator performance and cooling loads, validation of power system transient response for vehicle performance and mapping of fuel consumption for the power system.

The P&E SIL is another proactive TARDEC investment that the FCS program has leveraged for state-of-the-art testing of combat vehicle hybrid power propulsion systems at the whole system level.

TARDEC's EGTL was configured from the onset specifically for FCS engine/generator testing. The cell has a custom-built load bank capable of 600 kilowatt (kW) power absorption. It has a custom inverter system consisting of 4 Emerson industrial inverters with a power absorption capability of 500 kW and a current rating of 880 amperes. The cell has a customized high-pressure fuel system capable of delivering fuel at 11 bar and 3 cooling system loops to meet FCS propulsion system requirements.

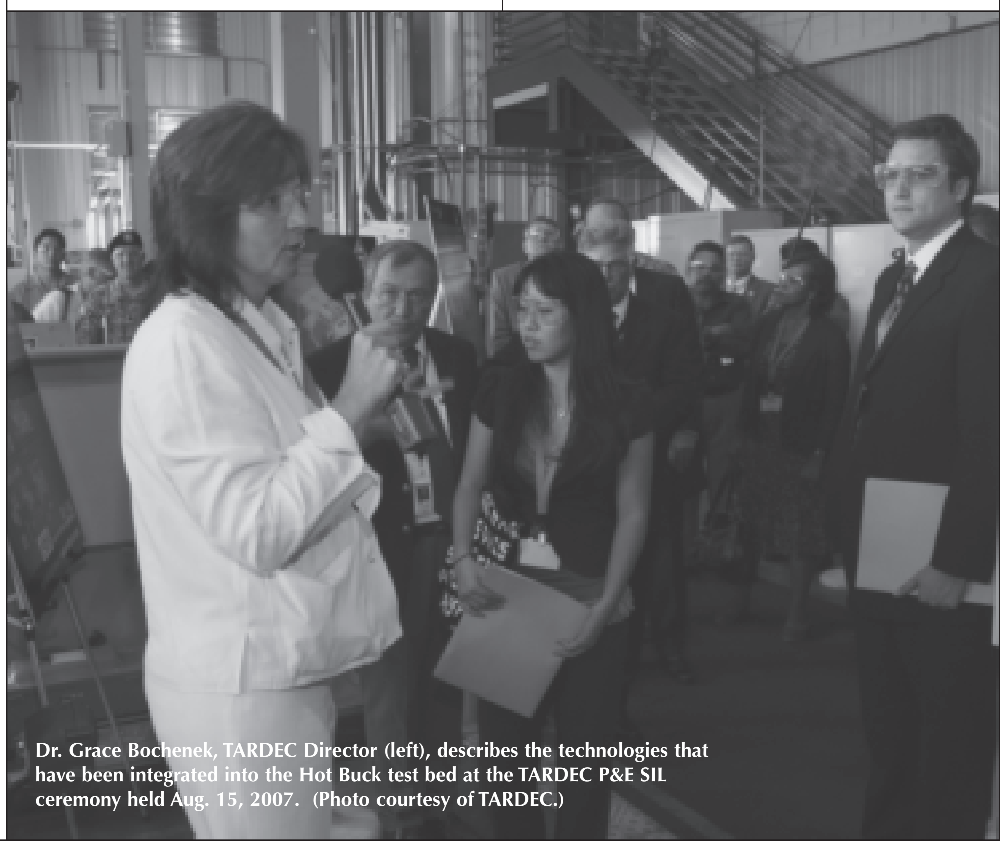
Two high-speed data acquisition systems acquire the data (300 low-speed and 120 high-speed channels capable of sampling the data at 1,000 hertz). The high-speed data acquisition can perform engine combustion analysis up to 2 million samples per second. These advanced facilities provide FCS vehicle integrators with very high fidelity data to validate performance, incorporate the data into FCS modeling and simulation efforts, and refine the propulsion system architecture development.

TARDEC Power and Energy System Integration Laboratory (P&E SIL)

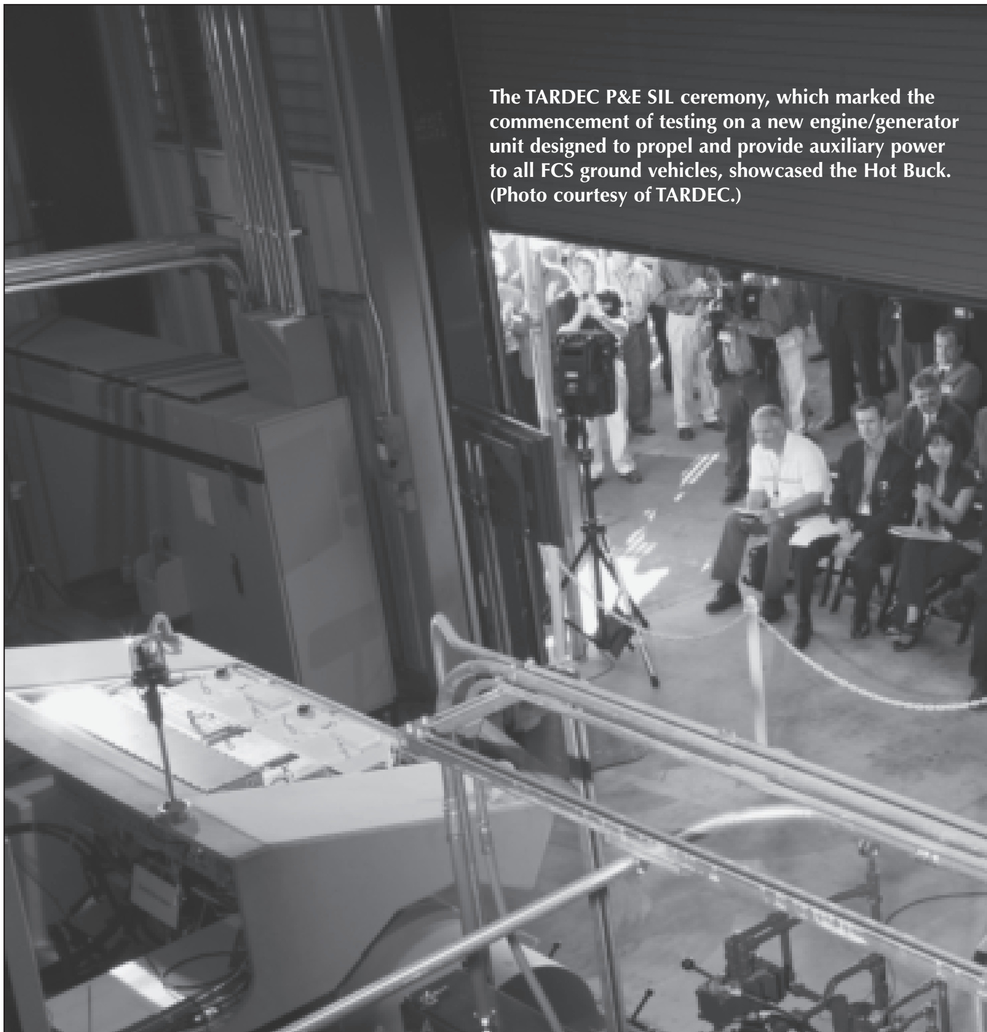
The P&E SIL is another proactive TARDEC investment that the FCS program has leveraged for state-of-the-art testing of combat vehicle hybrid power propulsion systems at the whole system level. Located in the heart of Silicon Valley, the P&E SIL is a companion lab to TARDEC's Michigan facilities, which are strategically at the heart of the world's automotive capital. The SIL maximizes the Army's ability to tap into the technical expertise that both locations offer.

The SIL was built in 1995 to support the Defense Advanced Research Projects Agency's (DARPA's) Combat Hybrid Power System program. In 2000, DARPA transitioned the facility to the Army, and specifically to TARDEC. Initially, the lab focused on hybrid electric system component-level research, development and testing of electric motors, power electronics and high-power/high-energy batteries. Since then, TARDEC and its "One Team" partners — including the FCS Brigade Combat Team, Boeing, BAE Systems, General Dynamics Land Systems and Science Applications International Corp. — have matured the SIL to allow for subsystem, and now for full system, hybrid electric research and development.

All along, TARDEC has been transitioning the SIL's data and results to the FCS program, while constantly refining and maturing the base technologies. In August, a fully integrated engine/generator system was installed in the SIL's "Hot Buck," a one-of-a-kind virtual FCS test bed platform, for full load testing. This represents the first time that real FCS hardware is integrated into a full hybrid electric power system in a vehicle platform, and is an example of true technology transfer. The engine and generator data produced by TARDEC's EGTL is being fed into the SIL's 440 kW hybrid drive system. In turn, TARDEC test equipment connected to the Hot Buck is providing critical data on FCS hardware operational capabilities before that hardware is installed in the first FCS vehicle.



Dr. Grace Bochenek, TARDEC Director (left), describes the technologies that have been integrated into the Hot Buck test bed at the TARDEC P&E SIL ceremony held Aug. 15, 2007. (Photo courtesy of TARDEC.)



The TARDEC P&E SIL ceremony, which marked the commencement of testing on a new engine/generator unit designed to propel and provide auxiliary power to all FCS ground vehicles, showcased the Hot Buck. (Photo courtesy of TARDEC.)

Another important SIL benefit is its ability to develop system models to evaluate performance, and to define and develop the software required to operate this very complex propulsion system. Today, the SIL is operating the FCS Hot Buck platform to help work through system integration issues, as well as to iterate and optimize the FCS propulsion system design. This FCS platform is used for testing, evaluating and collecting valuable data on FCS hardware operational capability before it is integrated into the first FCS vehicle.

Investing in the Future

The EGTL and P&E SIL are redefining how the Army develops and tests future propulsion systems. In the past, the only testing option was to simply run a propulsion system or component test and collect basic power data at different temperatures and speeds. Today, as the technologies are advancing, so is TARDEC's investment in testing equipment and processes.

The Army must have systems that can deliver fuel at high pressures and absorb electrical power at 750 volts direct current, and must be able to measure and control large power generation, energy storage and energy recovery. Army Test Operating Procedures (TOPs) must also be reviewed for applicability to new technology. For example, the Army is currently changing its fuel economy TOP to be suitable to test fuel economy of hybrid electric vehicles. Reliability and safety testing have begun on the lithium ion batteries needed for FCS and other current platforms.

These investments in advanced facilities and reengineering of current testing methods and procedures are laying the groundwork for future technology transitions to the warfighter. Technology improvements such as high-temperature silicon carbide power electronics and other advanced technologies will lead the way to achieving a propulsion system power density goal of 8-10 net horsepower/cubic feet for the future. This combination of technology improvements, facility advancements, updated testing methods, and Army and industry cooperation and collaboration — early in the S&T development process — are critical to transitioning the latest technologies to the battlefield as quickly and efficiently as possible.

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